

**Preliminary Assessment of Energy Requirements and
Environmental Releases for Four Alternative Steelmaking Technologies**

July 27, 1999

Gary A. Amendola, P.E.
Amendola Engineering, Inc.
Rocky River, Ohio

Preliminary Assessment of Energy Requirements and Environmental Releases for Four Alternative Steelmaking Technologies

Objective: Compare energy requirements and environmental releases for four alternative steelmaking technologies incorporating processes that are currently available on a commercial scale.

Basis: Production 1,000,000 tons of crude (molten) steel.

Alternative Steelmaking Processes

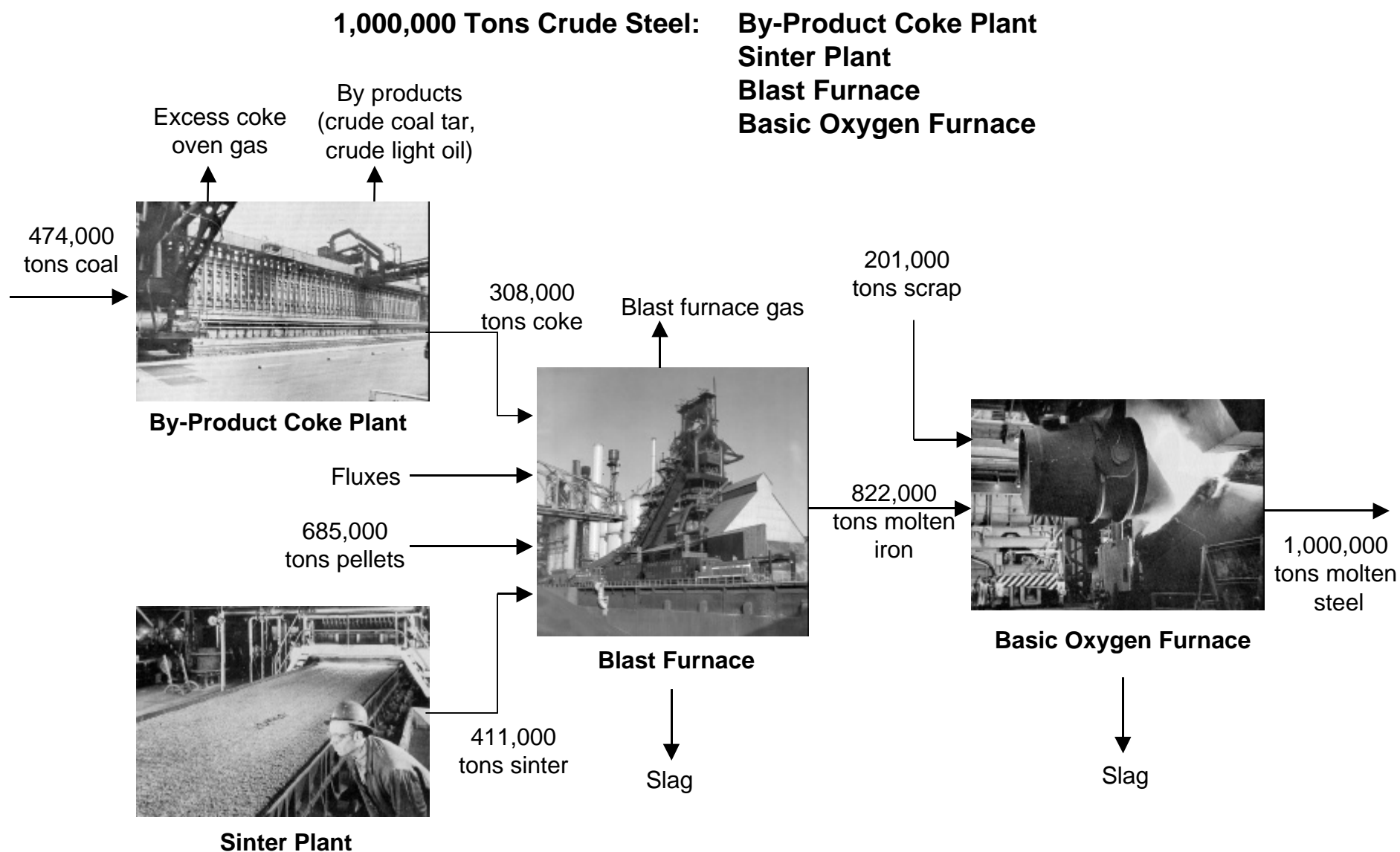
Figure 1 - Blast Furnace/BOF Steelmaking
with By-Product Coke Plant

Figure 2 - Blast Furnace/BOF Steelmaking
with Heat Recovery Coke Plant

Figure 3 - EAF Steelmaking with 100% Scrap Charge

Figure 4 - EAF Steelmaking with 60% Scrap; 40% DRI Charge

Figure 1
Approximate Material Balance



Sources: *Iron and Steel Engineer.*
The Making, Shaping, and Treating of Steel, 10th Edition.

1,000,000 Tons Crude Steel:	Heat Recovery	Coke Plant
	Sinter Plant	
	Blast Furnace	
	Basic Oxygen Furnace	

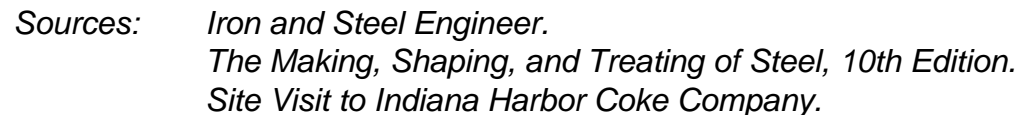
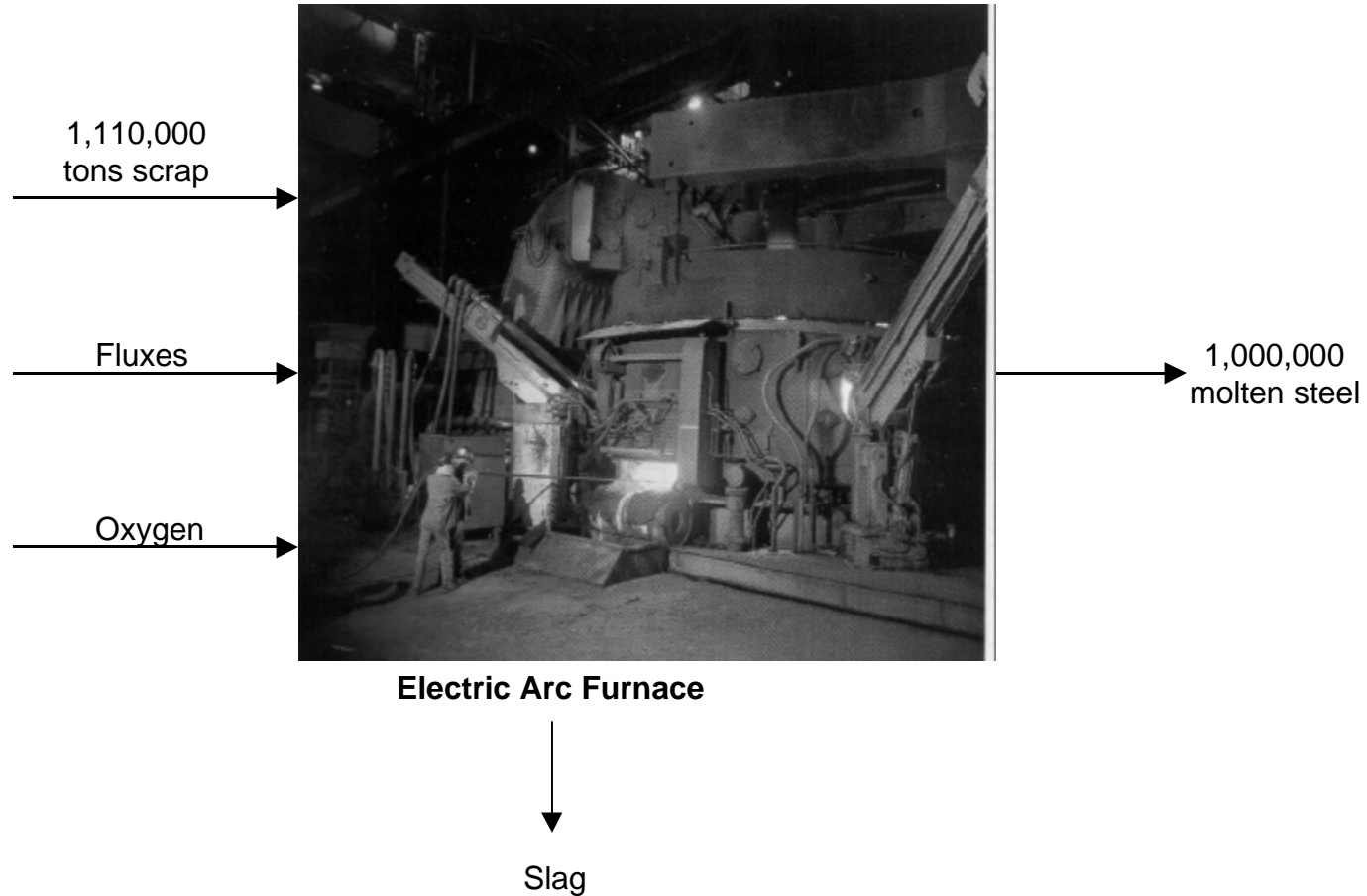


Figure 3
Approximate Material Balance

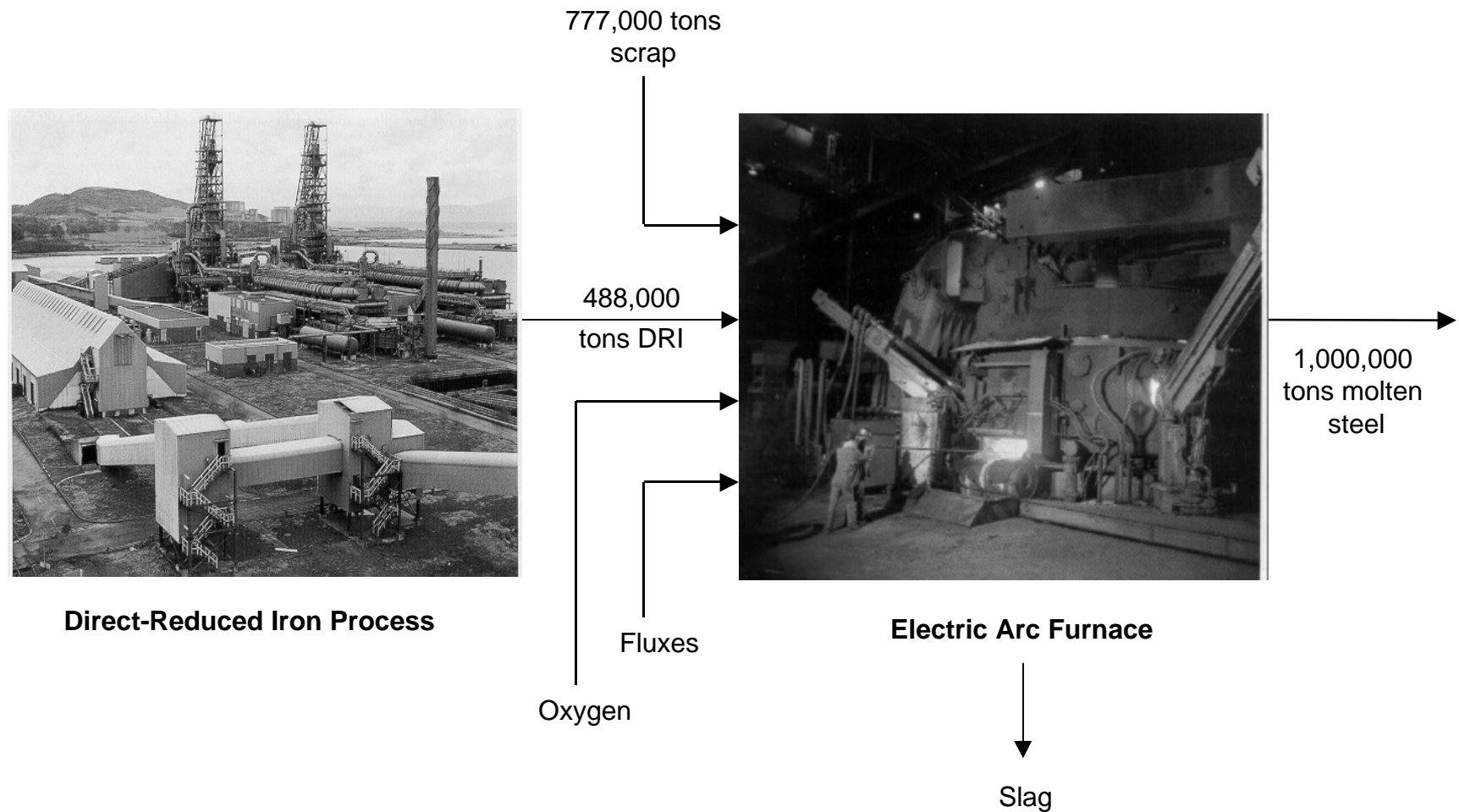
1,000,000 Tons Crude Steel: Electric Arc Furnace



Source: Iron and Steel Engineer.

Approximate Material Balance

**1,000,000 Tons Crude Steel: Direct-Reduced Iron Process
Electric Arc Furnace**



Source: Iron and Steel Engineer.

Alternative Steelmaking Processes

Principal Raw Materials

Basis: 1,000,000 tons of molten steel

	Figures 1 & 2	Figure 3	Figure 4
Coal	474,000 tons		
Coke (w/o breeze)	308,000 tons		
Pellets	685,000 tons		
Sinter	411,000 tons		
Molten Iron	822,000 tons		
Steel Scrap	201,000 tons	1,110,000 tons	777,000 tons
DRI			488,000 tons
Molten Steel	1,000,000 tons	1,000,000 tons	1,000,000 tons

Net Energy Requirements to Make 1,000,000 tons of Molten Steel

1.99×10^{13} BTU - Blast Furnace/BOF Steelmaking with By-Product Coke Plant

2.09×10^{13} BTU - Blast Furnace/BOF Steelmaking with Heat Recovery Coke Plant

2.24×10^{13} BTU - EAF with 100% Scrap Charge

2.82×10^{13} BTU - EAF with 60% Scrap; 40% DRI Charge

Notes:

- (1) Estimates account for initial energy required to manufacture steel used as scrap.
- (2) Credit provided for excess coke oven gas and crude coal tar and light oil for by-product cokemaking.
- (3) Credit provided for energy generated from heat recovery coke plant.

Figure 1
Energy Requirements to Produce 1,000,000 Tons of Crude Steel

Blast Furnace/BOF Steelmaking With By- Product Coke Plant	Materials	Energy Requirement (BTU)	Process Total (BTU)
Coke Plant	Coal	1.27×10^{13}	1.27×10^{13}
	Electricity	3.68×10^{10}	
Blast Furnace	Furnace Coke		5.01×10^{12}
	Natural Gas	2.05×10^{11}	
	Coal (PC1)	2.75×10^{12}	
	Iron Values (including sinter)	1.41×10^{12}	
	Electricity for Sinter Plant	1.76×10^{11}	
	Oxygen	4.04×10^{11}	
	Electricity	7.01×10^{10}	
	Hot Blast/Blast Furnace Gas	Net of Zero	

Figure 1 (cont.)
Energy Requirements to Produce 1,000,000 Tons of Crude Steel

Blast Furnace/BOF Steelmaking With By- Product Coke Plant	Materials	Energy Requirement (BTU)	Process Total (BTU)
Basic Oxygen Furnace – SC	Cold Steel Scrap	3.69×10^{12}	4.34×10^{12}
	Lime Products		
	Molten Iron		
	Oxygen	5.52×10^{11}	
	Electricity	1.02×10^{11}	
Total Energy Requirement			2.21×10^{13}
Energy Credits			
Coke Oven Gas			1.49×10^{12}
By-products (crude coal tar, light oil)			7.29×10^{11}
Net Energy Requirement			1.99×10^{13}

Note: Estimates account for energy required to manufacture steel used as scrap charge.

Figure 2
Energy Requirements to Produce 1,000,000 Tons of Crude Steel

Blast Furnace/BOF Steelmaking With Heat Recovery Coke Plant	Materials	Energy Requirement (BTU)	Process Total (BTU)
Coke Plant	Coal	1.27×10^{13}	1.27×10^{13}
	Electricity	3.68×10^{10}	
Blast Furnace	Furnace Coke		5.01×10^{12}
	Natural Gas	2.05×10^{11}	
	Coal (PCI)	2.75×10^{12}	
	Iron Values (including sinter)	1.41×10^{12}	
	Electricity for Sinter Plant	1.76×10^{11}	
	Oxygen	4.04×10^{11}	
	Electricity	7.01×10^{10}	
	Hot Blast/Blast Furnace Gas	Net of Zero	

Figure 2 (cont.)
Energy Requirements to Produce 1,000,000 Tons of Crude Steel

Blast Furnace/BOF Steelmaking With Heat Recovery Coke Plant	Materials	Energy Requirement (BTU)	Process Total (BTU)
Basic Oxygen Furnace – SC	Cold Steel Scrap	3.69×10^{12}	4.34×10^{12}
	Lime Products		
	Molten Iron		
	Oxygen	5.52×10^{11}	
	Electricity	1.02×10^{11}	
Total Energy Requirement			2.21×10^{13}
Energy Credits			
Electricity Production			6.69×10^{11}
Steam			5.55×10^{11}
Net Energy Requirement			2.09×10^{13}

Note: Estimates account for energy required to manufacture steel used as scrap charge.

Energy Requirements to Produce 1,000,000 Tons of Crude Steel

Figure 3. EAF Steelmaking with 100% Scrap Charge

Materials	Energy Requirement (BTU)
Cold Steel Scrap	1.43×10^{13}
Electricity	5.09×10^{12}
Oxyfuel Burners	6.10×10^{11}
Carbon and chemical reactants	2.44×10^{12}
Total Energy Requirement	2.24×10^{13}

Figure 4. EAF Steelmaking with 60% Scrap; 40% DRI Charge

Materials	Energy Requirement (BTU)
DRI	6.94×10^{12}
Cold Steel Scrap	1.31×10^{13}
Electricity	5.09×10^{12}
Oxyfuel Burners	6.10×10^{11}
Carbon and chemical reactants	2.44×10^{12}
Total Energy Requirement	2.82×10^{13}

Note: Estimates account for initial energy required to manufacture steel used as scrap charge.

Comparison of Selected Air Emissions - By-Product and Heat Recovery Cokemaking

Pollutant	By-Product Coke Plant (lbs)	Heat Recovery Coke Plant (lbs)
Anthracene	62	
Ammonia	8,711	
Benzene	6,342	140
Benzo-a-pyrene		100
Benzene soluble organics		460
Cyanide compounds	434	
Ethylene	4,216	
Ethylbenzene	62	
Methanol	6,231	
Naphthalene	713	260
Phenol	217	
Propylene	465	
Xylene (mixed isomers)	372	
Other PAHs	20	

Basis: (1) By-product coke plant: EPA TRI Database, 1997 - median emissions from six by-product coke plants; EPA 1997 Iron and Steel Survey.

(2) Heat recovery coke plant: *Air Pollution Engineering Manual*, Van Nostrand Reinhold, 1992, pp. 613,616, 643.

Alternate Steelmaking Technologies

Effluent Comparison

Basis: 1,000,000 tons of steel

Wastewater Discharges (lbs)	Figure 1 Integrated Steelmaking with By-Product Cokemaking	Figure 2 Integrated Steelmaking with Heat Recovery Cokemaking	Figure 3 EAF Steelmaking
TSS	58,754	32,633	No process wastewater generated
Oil and Grease	6,262	4,521	
Ammonia (N)	13,395	10,624	
Total Cyanide	1,142	53	
Phenols (4AAP)	63	59	
Total Lead	148	148	
Total Zinc	258	218	
Benzene	16		
Benzo(a)Pyrene	9		
Napthalene	2		

Note: Based on EPA Development Document long term average values.

**Preliminary Assessment of Energy Requirements and
Environmental Releases for Four Alternative Steelmaking Technologies**

July 27, 1999

Gary A. Amendola, P.E.
Amendola Engineering, Inc.
Rocky River, Ohio